FIRST DRAFT

SEDIMENT MANAGEMENT, RESOURCE MANAGEMENT STRATEGY

Note: This draft is under review by the Sediment Management Subject Matter experts. Additional edits will be provided at the June 7 workshop.

REVIEWER INSTRUCTIONS

Dear Sediment Resource Management Strategy Chapter Reviewers:

Thank you for assisting with this brand new Water Plan Chapter. Following are some reviewers' instructions.

The primary text is 16 pages with the remainder of the text being reviewer instructions, references, case studies and suggested pictures.

When you read, please keep the following in mind:

1. Audience - this chapter will have several primary audiences:
    a) College Students looking for background information on water management strategies
    b) Water Managers looking for background information on alternative water management strategies, and also looking for options to comply with grant requirements for integrated water management
    c) Staff of the Legislature that use this text for bill analysis and to suggest potential new legislation.
    d) Agency staff that may use the chapter as part of a budget justification
2. The Audience may or may not have familiarity with the topic so terms need definition if they are not words used in everyday conversations. For this reason much of the technical information that many of you provided for the chapter has been translated to lay person terms or terms are defined in text or endnotes.
3. Please read the text with a particular eye to text that may not correctly present an idea due to an improper translation or to a cut and paste error. This type of problem is likely as information is drawn from many sources and the translation of technical information to lay terms is inherently hazardous.
4. Do NOT be concerned with general editing or wordsmithing. Once you are done with your review and we complete the public workshop, the document will be professionally edited. At this early stage of the document, and with so many authors, it would be

difficult to do any editing that would not result in different people editing the same sections differently.

5. DO read for content -we need to make the case that sediment management is a critical WATER MANAGEMENT strategy. Your review and augmentation of the text for that purpose is important.

6. Please help me fill in holes in the text. They are well marked. In particular we really need information on costs.

7. Additional instructions for document section are also provided in the text.

Thank you again for your support. As always, please let me know if you have any questions.

Sincerely,

Lisa Beutler, *Executive Facilitator*
California Water Plan Update 2013

& Water Resources Group
MWH Americas

Chapter Y - Sediment Management

NOTE TO REVIEWERS

This section needs to meet the following requirements:

1. Defines what Sediment and Sediment Management is.
2. Explains how Sediment in managed in California.
3. Demonstrates the very different approaches to Sediment management based on the purpose of the management and the location of the sediment in the system.
4. Makes a case as to why sediment management is a concern of water managers.

Please read this section for:

- Accuracy (are descriptions accurately translated from more technical documents into this more general format? If not, what is the correct translation?)
- Accessibility of language (is this written in the right tone and level for the intended audience?)
- Flow of text (does the flow generally make sense? For example are things presented in a logical order such as sediment/ sediment and Erosion/ Sediment and Flood/ etc.)
- Logical segmentation (the descriptions are written by the type of management, are these the best categories to explain the management approach? What, if anything should be added, subtracted of changed?)

Sediment Management in California

Sediment are finely divided materials created by weathering and erosion, and moved by wind, water, or ice, and/or by the force of gravity. It can come from anywhere and be just about anything. Organic and inorganic material alike can become the bits of matter tiny enough to allow it to be picked up and carried along with a moving fluid.

From a human perspective, sediment has a dual nature—desirable in some locations and unwanted in others. Sediment can be used to create or restore beaches and to renew wetlands and other coastal habitats. Such activities are referred to as beneficial uses. Undesirable sediment can cloud water and degrade wildlife habitat, form barriers to navigation, and contaminate the food chain for marine plants, animals, and humans.

Whether sediment is desirable or not, its location and movement can have large economic and ecological consequences. For example, excess sediment in shipping channels may cost ports millions of dollars in delayed or limited ship access, while in other locations insufficient sediment deposits could result in the loss of valuable coastal wetlands.[i]

Erosion and Sedimentation

The process of erosion and sedimentation is inevitable. For as long as there have been wind and water, there has been erosion. Erosion has shaped our valleys and mountains and will continue to, despite the best efforts of humans. Erosion and the resulting sedimentation is a natural process that is the major factor in the ever-changing face of the earth.

Erosion is defined as: "The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep," and sedimentation as: "The process by which mineral or organic matter is removed from its site of origin, transported, and deposited by wind, water or gravity" (California Resources Agency 1978).

Erosion is a natural process, which generally proceeds at a slow rate unless a large-scale vegetation disturbance occurs (e.g., as a result of wildfire or intentional land clearing activities). Human activities in a watershed can greatly accelerate the rate and amount of erosion.

The potential for erosion is determined by soil characteristics (such as particle size and gradation, organic content, soil structure, and soil permeability), vegetative cover, topography (slope length and steepness), and the frequency, intensity, and duration of precipitation.

Rivers and streams carry sediment in their flows. This sediment can be in a variety of locations within the flow, depending on the balance between the upwards speed on the particle (drag and lift forces), and the settling speed of the particle.

Fluvial processes are the movement of sediment, organic matter, and erosion that deposits on a river bed, and the land forms this creates.

In some cases depending on the velocity sediment will be transported downstream entirely as suspended load. In other cases it will move along the water bed as bed load by rolling, sliding, and saltating (jumping up into the flow, being transported a short distance then settling again). It may also move as a wash load.

There are generally a range of different particle sizes in the flow. It is common for material of different sizes to move through all areas of the flow for given stream conditions.

Suspended load is the portion of the sediment that is carried by a fluid flow which settle slowly enough such that it almost never touches the bed. It is maintained in suspension by the turbulence in the flowing water and consists of particles generally of the fine sand, silt and clay size.

B**ed load** describes particles in a flowing fluid (usually water) that are transported along the bed of a waterway.

Wash load is the portion of sediment that is carried by a fluid flow, usually in a river, such that it always remains close the free surface (near the top of the flow in a river). It is in near-permanent suspension and is transported without deposition, essentially passing straight through the stream. The composition of wash load is distinct because it is almost entirely made up of grains that are only found in small quantities in the bed. Wash load grains tend to be very small (mostly clays & silts but some fine sands) and therefore have a small settling velocity, being kept in suspension by the flow turbulence.

Sediment management in California is critical for the entire watershed, beginning with the headwaters and continuing into the coastal shores. Active management may occur to benefit fisheries, water supply, navigation, flood management, navigation and/or beach replenishment.

Surface water sedimentation affects beneficial uses by increasing turbidity, and physically altering streambed and lakebed habitat. Sediment affects sight-feeding predators in their ability to capture prey, clogs gills and filters of fish and aquatic invertebrates, covers and impairs fish spawning substrates, reduces survival of juvenile fish, reduces fishing success, and smothers bottom dwelling plants and animals.

Nutrients (such as phosphorus) and trace metals are often associated with sediment. In some cases suspended sediment particles increase growth of bacteria which can concentrate these nutrients from the water column. Toxic pollutants from storm water may also deposit in sediments. Concentrated pollutants can greatly impair water quality if they are remobilized back into the environment.

Sediment can reduce the hydraulic capacity of stream channels, causing an increase in flood crests and flood damage. It can fill drainage channels, especially along roads, plug culverts and storm drainage systems, and increase the frequency and cost of maintenance. Sedimentation can decrease the useful lifetime of a reservoir by reducing storage capacity for municipal supplies and increasing treatment costs to remove turbidity. Sedimentation of harbors and drainage systems results in higher maintenance costs and potential problems associated with disposal of removed material. The accumulation of sediment in recreational lakes affects boating activity in the shore zone, and can lead to demands for dredging to deepen marinas and channels.

A **point bar** is a depositional feature of streams. Point bars are found in abundance in mature or meandering streams. They are crescent-shaped and located on the inside of a stream bend.

Point bars are composed of sediment that is well sorted. They have a very gentle *slope* and an elevation very close to water level. Since they are low-lying, they are often overtaken by floods and can accumulate driftwood and other debris during times of high water levels.

They are often popular rest stops for boaters and rafters. However, camping on a point bar can be dangerous as a flash flood that raises the stream level by as little as a few inches can overwhelm a campsite in moments.

Sediment and Flood

Sediment management is a key consideration in flood management. Historic flood deposits of sediment into floodplains are the source of much of California’s richest farmland. When a river breaks its banks and floods, it leaves behind layers of mud and rock. These gradually build up to create the floor of the flood plain. Floodplains generally contain unconsolidated sediments, often extending below the bed of the stream. These are accumulations of sand, gravel, loam, silt, and/or clay, and are often important aquifers, the water drawn from them being pre-filtered compared to the water in the river.

Geologically ancient floodplains are often represented in the landscape by fluvial terraces. These are old floodplains that remain relatively high above the present floodplain and indicate former courses of a stream.

Forming floodplains are marked by meandering streams, ox-bow lakes and point bars, marshes or stagnant pools. Occasionally they are completely covered with water. When the drainage system has ceased to act or is entirely diverted for any reason, the floodplain may become a level area of great fertility.

When floodplains are separated from the water source, through levees or other means, the natural process of equilibrium (which elevates the land through sediment deposits) is halted. This means that while flooding may not occur as frequently, when the separation is ultimately breached, flooding is typically extreme and damaging.

At the same time, in some cases sediments remain in within the restrained channel, settling and reducing the capacity of the channel, increasing the likelihood of a water breach and flood. In many cases this is avoided by dredging of the channel and then mechanically depositing the sediment in desirable locations.

Alluvial fans develop where streams or debris flows gather speed in narrow passages then emerge into areas with greatly larger channel widths. Debris and water spill out in a fan shape depositing sediment and other debris on its way. The channels on these fans range from decimeters to several meters deep with the speed of the flows moving boulders sometimes taller than a house. In California these conditions are found at mountain fronts, in intermountain basins, and at valley junctions. Alluvial Fans are found where sediment loads are high, for example, in arid and semiarid mountain environments, wet and mechanically weak mountains, and environments that are near glaciers.

Historic Context

Many California sediment management issues trace back to historic gold dredge activities beginning in the 1850's. California's Central Valley and Bay-Delta waterways experienced significant alteration caused by tons of debris sent downstream from mining operations. Impacts from these activities continue today. Beyond the Delta and Central Valley, impacts from early road building and land management practices continue to contribute to existing problems. Additional system alterations also occured as dams and channels were built for both water supply and flood protection. More and more structures changed what had been the natural hydrology, which then altered whatever system stability for sediments may have existed. So the function of waterways to produce sediment, flush it through the system with some settling occurring in low areas to create rich farmland, and some moving to the sea to create shoreline replenishment, is disrupted.

Management Focus

Today, California sediment management typically occurs at three scales, upland, in-stream, and wetland, coastal. The activities and agencies involved vary slightly and typical the activities occur at disparate geographic locations.

Upland Management

Upland management occurs to prevent soil loss and adverse sediment flows from land use activities that may, without proper management, cause excessive sediment movement. Routine upland activities and practices such as recreation, roads and trails, grazing, farming, forestry and construction, if not properly managed could be an adverse sediment source. As noted above, other excessive flows may result from land based events such as extreme fire incidents, high water volumes, wind, and other events.

Farmers and transportation and recreation professionals are aware that soil loss is an economic as well as an environmental problem. Even so, many homeowners and other stakeholders may not be aware of this unless their homes and neighborhood streets are damaged by mudslides or stream bank or lakeshore erosion. Understanding the cumulative impacts of all past, present, and proposed human activities in watershed is important in predicting the impacts of erosion on surface waters.

On the federal side, the US Department of Agriculture, Forest Service and Natural Resources Conservation Service, and the federal Bureau of Land Management and US Geological Service, all actively support California land management practices that incorporate sediment management. The US Fish and Wildlife Service, through its Landscape Conservation Cooperatives is also engaged. Local entities, particularly Resource Conservation Districts, provide direct support for land managers as do stakeholder organizations such as the California and local Farm Bureaus and California Rangeland Trust. Other local and regional planning bodies, such as the Sierra Nevada Conservancy, Tahoe Regional Planning Agency and local planning commissions, are able to support land use planning that in turn supports good sediment management.

Many State agencies and commissions are also actively engaged in upland sediment management work. Most notably CalFIRE and the Board of Forestry and Fire Protection (BOF). The for over 20 years, a group of advisors called the Monitoring Study Group (MSG) has, and continues, to: (1) develop a long-term program testing the effectiveness of California's Forest Practice Rules, and (2) provide guidance and oversight to the California Department of Forestry and Fire Protection (CAL FIRE) in implementing the program. The MSG has sponsored significant research on sediment management. This research informs CAL FIRE funded monitoring efforts designed to ascertain if forest practice rules protecting beneficial uses of water are being implemented and are effective.

The Department of Food and Agriculture, Water Boards, and the Department of Conservation provides significant leadership in this area through ____ [Need Text].

A significant source of sediment is from urban run-off. The California Association of Storm Water Quality Agencies (CASQA) assists the State Water Resources Control Board (SWRCB) and municipalities throughout the state of California in implementing the National Pollutant Discharge

Elimination System (NPDES) stormwater mandates of the Federal Clean Water Act. In fulfilling this purpose, CASQA recommends objectives and procedures for stormwater discharge control programs which are (1) technically and economically feasible, (2) provide significant environmental benefits and protect the water resources, (3) promote the advancement of stormwater management technology, and (4) effect compliance with State and Federal laws, regulations and policies

One of the accomplishments of CASQA has been the development and dissemination of Best Management Practices (BMP) Handbooks. These handbooks are designed to provide guidance to the stormwater community in California regarding BMPs for a number of activities affecting water quality and sediment management, including New Development and Redevelopment, Construction Activities, Industrial and Commercial Activities, and Municipal Activities. CASQA Web sites: CASQA websites are at http://www.casqa.org/ and http://www.cabmphandbooks.com/.

Some local governments (city and county) have also begun to support Low Impact Development (LID). They have included LID as part of their planning and development ordinances. LID features design elements, including hydromodification, that address sedimentation at the source. Many resources, including model regulations, are available to help municipalities interested in incorporating LID and sediment management into their planning portfolios.[ii]

In-Stream Sediment Management

In-stream sediment management occurs to remove and/or management settled sediments from behind dams where siltation has dramatically impacted both water supply and flood management capacity. Similar concerns about water supply and flood capacity exist for silted water channels, as well as concerns about reductions in navigability. The US Army Corps of Engineers maintains primary jurisdiction for waterway and navigational concerns and specific interests for many dams, with the Bureau of Reclamation also maintaining a significant federal role in this area. The state Department of Water Resources and the State Lands Commission serve as state counter-parts to the federal agencies with other agencies, such as the U.S. EPA and State Water Boards, and State and federal agencies responsible for fisheries and recreation.

Dam Removal and Sediment Management

There has been substantial interest in recent years related to dam removals. Analysis of dam removal proposals features significant discussion of sediment management. Over XXX dams (that are at least 6 feet in height) exist in California today, and they serve many different purposes.[iii] These purposes include water supply for irrigation, municipal, industrial, and fire protection needs; flood control; navigation; recreation; hydroelectricity; water power; river diversion; sediment and debris control; and waste disposal (Heinz Center, 2002 and American Society of Civil Engineers (ASCE), 1997).

While the great majority of these dams still provide a vital function to society, some of these dams[iv] may need to be decommissioned for various reasons including:

- Economics
- Dam safety and security

- Legal and financial liability
- Recreation
- Ecosystem restoration (including fish passage improvement)
- Site restoration (including to rehabilitate cultural or historic properties)

Once a decision to investigate dam removal made, sediment management becomes a major concern. Reservoir sediment disposal (through mechanical methods) can be very costly for large volumes of

sediment. Therefore, the management of reservoir sediment is often an important and controlling issue related to dam removal (ASCE, 1997). The sediment erosion, transport, and deposition are likely to be among the most important physical effects of dam removal (Heinz Center, 2002).[v]

Sediment related impacts associated with dam decommissioning may occur in the reservoir and in the river channel, both upstream and downstream from the reservoir. Depending on the local conditions and the decommissioning alternative, the degree of impact can range from very small to very large. For example, the removal of a small diversion dam that had trapped only a small amount of sediment would not have much impact on the downstream river channel. If only the powerplant of a dam were decommissioned, then sediment-related impacts would be very small. The top portion of a dam might be removed in such a way that very little of the existing reservoir sediment would be released into the downstream river channel. In this case, the impacts to the downstream river channel might be related only to the future passage of sediment from the upstream river channel through the reservoir. If dam removal resulted in a large quantity of sediment being released into the downstream river channel, then the impacts to both the upstream and downstream channels could be significant.[vi]

The development of alternative sediment management plans for dam decommissioning requires concurrent consideration of engineering and environmental issues.

Dredging and Sediment Management

Dredging and sediment management is a critical activity supporting commercial shipping, homeland security, fishing, recreation and more. In just the San Francisco Bay/Delta Estuary these activities fuel a substantial maritime-related economy of over $7.5 billion annually. However, the facilities supporting these activities are located around the margins of a bay system that averages less than 20 feet deep, while modern, deep-draft ships often draw 35 to 40 feet of water or more. Extensive dredging — in the range of 2 million to 10 million cubic yards (mcy) per year — is therefore necessary to create and maintain adequate navigation channels in order to sustain the region's diverse navigation-related commercial and recreational activities. Effective management of the large volumes of dredged material generated throughout the Estuary is a substantial challenge.[vii]

Similarly ____NEED INFORMATION FROM OTHER MAJOR NAVIGATIONAL CHANNELS - Especially Southern California but also Nor Cal Waterways and ports.

Dredging involves three stages, excavation, transport, and placement of dredged sediments. The excavation process commonly referred to as "dredging" involves removing sediment in its natural or recently deposited condition. After the sediment, also called spoils, has been excavated, it is transported from the dredging site to a destination where it may be reused or a disposal area. This may occur in either open-water, nearshore, or upland locations. Determining how the spoils will be managed involves a variety of factors related to the dredging process including environmental acceptability, technical feasibility, and economic feasibility.[viii]

Dredging directly impacts water quality, sediment management and contaminant control. Dredging operations may reduce water quality by introducing turbidity, suspended solids, and other variables that affect the properties of the water such as light transmittance, dissolved oxygen, nutrients, salinity, temperature, pH, and concentrations of trace metals and organic contaminants if they are present in the sediments (U.S. Navy 1990).

Depending on the location of the dredging, deepening navigation channels can increase saltwater intrusion (since saline water is heavier than freshwater), potentially impacting freshwater supplies and fisheries. Dredging can also increase saltwater intrusion into groundwater aquifers (e.g., the Merritt Sand/Posey formation aquifer in the Oakland Harbor area), with consequent degradation of groundwater quality in shallow aquifers (U.S. Navy 1990).

The impacts on sediments at the dredging site may include increased post-dredging sedimentation in the newly deepened areas for new work projects, local changes in air-water chemistry, and possible slumping of materials from the sides of the dredging areas.

Dredging may reintroduce contamination into the water system by re-suspending pollutants. Metal and organic chemical contamination is widespread in urban shipping channels due to river run-off and municipal/ industrial discharges. Chemical reactions that occur during dredging may also change the form of the contaminant. These chemical reactions are determined by complex interactions of environmental factors, and may either enhance or decrease bioavailability, particularly of metals.

In California, dredge spoils, while potentially a dilemma to dispose of may also be repurposed for significant benefits when used as fill for a variety of purposes. When this occurs the economics of disposal may be altered. Interestingly when the introduction of benefit may also increase a real cost for sediment removal as the sediment may be a public trust asset[ix] and thus subject to mineral extraction fees and other restrictions.

Coastal Management

The California Coastal Sediment Management Workgroup (CSMW) was established by the U.S. Army Corps of Engineers (Corps) and the California Resources Agency (Resources Agency) in 1999 to develop regional approaches to protecting, enhancing and restoring California's coastal beaches and watersheds through federal, state and local cooperative efforts.

The mission of the CSMW is to identify and prioritize regional sediment management needs and opportunities along the California coast, and provide this information to resource managers and the general public . The goals is to assist in addressing coastal sediment management issues, and develop strategies to streamline sediment management activities. Such issues may include coastal erosion, recreational opportunities, dredging, and sediment flow through coastal watersheds.

The CSMW was formed in response to concerns about shore protection needs in California. The consensus was that coastal sediment management is a key factor in developing strategies to conserve and restore California's coastal beaches and watersheds.

In addition to the Corps and the Resources Agency (including Agency departments and Commissions such as the Ocean Resources Management Program, Department of Boating and Waterways, Department of Park and Recreation, California Coastal Commission, State Lands Commission, State Coastal Conservancy, California Geologic Survey and Department of Fish and Game.), the California Coastal Coalition (CalCoast) participates. This group is a non-profit organization comprised of cities, counties and regional government agencies along the coast. CalCoast advises the CSMW with local feedback and updates regarding projects and studies underway in coastal communities.

Other entities, including the federal Minerals Management Service and U.S. Geological Survey, and the California Department of Transportation (CalTrans), participate in an advisory capacity.

Together, the CSMW oversees the California Coastal Sediment Management Plan (SMP). The SMP will identify and prioritize Regional Sediment Management (RSM) needs and opportunities along the California coast, provide this information to resource managers and the general public, and streamline sediment management activities.

Tools, documents and RSM strategies developed to date are available on the CSMW website. Examples of assistance to Coastal managers from components of the SMP could include:

- Identifying and prioritizing sediment-related projects
- Navigating though environmental and regulatory review
- Developing opportunistic sand programs
- Developing Environmental Impact Statements and Assessments
- Developing governance needed for effective implementation of sediment management programs

Potential Benefits of Sediment Management

NOTES TO REVIEWERS -

This section needs to meet the following requirements:

1. Explains the benefits of using Sediment Management as a water manager strategy
2. Sets the stage for recommendations that say things like - "do more of this."

Please read this section for:

- Accuracy (are descriptions accurately translated from more technical documents into this more general format? If not, what is the correct translation?)
- Accessibility of language (is this written in the right tone and level for the intended audience?)

- Flow of text (does the flow generally make sense? Are things presented in a logical order?)
- Logical segmentation (the descriptions are written by the type of management, are these the best categories to explain the benefits? What, if anything should be added, subtracted of changed?)

As noted above sediment has a dual nature.

Too much sediment can lead to	Too little sediment can lead to	Sediment can also be used for
• obstructed channels • overflowing rivers • smothered reefs • high turbidity that blocks sunlight	• disappearing beaches • eroded riverbanks • wetlands losses • altered river profiles	• construction material • beach nourishment • wetland restoration • replacement of agricultural soil

The ultimate benefits of sediment management relate to preventing the negative results of too little or too much sediment and repurposing sediment for beneficial uses. As noted above, benefits associated with reducing impacts to navigation and commerce alone may achieve cost savings by millions of dollars.

Upland Sediment Management

Benefits of upland sediment management, to benefit land management are well understood by all land management agencies and related professional societies and organizations. An average of 1.3 billion tons of soil per year are lost from agricultural lands in the U.S. alone due to erosion.[x] Considering soil formation rates are estimated to be only 10–25% of these erosion rates (Jenny, 1980), loss and movement of soil by erosion is a major challenge for today's producers and land managers. Soil erosion over decades can have detrimental effects on productivity and soil quality because the majority of soil nutrients and soil organic matter (SOM) are stored in the topsoil, the soil layer most affected by erosion (NM 4, NM 15). For these reasons and more, sediment management for soil sustainability has numerous multiple benefits far exceeding the scope of the Water Plan.

In the case of urban land management, use of LID and other sediment management practices can reduce negative impacts of storm water run-off, by reducing sediment load and improving permeability of drainage areas. Land use goals for sediment may also improve flood management by improving the flood system hydrology.

In-stream and Coastal Sediment Management

In the coastal waterways sediment can serve to furnish material needed to replenish the beaches along the coastal areas. If the sediment is dredged from navigation channels or harbors the dredged material can be used for such construction purposes as highway sub-base material and flood control levees.

Improving the buffer zones of coastal areas reduces potential storm and climate change impacts. The dollar value of this improved protection is nearly incalculable, not just for those that own coastal structures, but for the stunning number of infrastructure improvements that support the state including power generation, major transportation assets, water systems, etc., and the dollar value of the recreation and tourism industries to the state's economy.

In terms of Water Management natural amounts of course-grained sediment (sand and gravel) that has entered the stream and river system has many beneficial uses. In the inland waterways it can serve as a substrate for fish spawning areas. Enhancing the sustainability of the fishery benefits not only the State's fishing industry but is also a water supply benefit as a declining fishery may lead to reductions of water exports.

Regional Sediment Management

Regional Sediment Management (RSM) refers to a practice where sediment is managed over an entire region in the most cost effective way. This is a growing concept nationwide and has economic benefits. It pertains to making the most economical use of clean dredged sediment within the region. The Army Corps of Engineers has a primer on Regional Sediment Management at: http://www.wes.army.mil/rsm/pubs/pdfs/rsmprimer.pdf.

RSM is an approach for managing projects involving sand and other sediments that incorporates many of the principles of integrated watershed resources management, applying them primarily in the context of coastal watersheds. While the initial emphasis of RSM was on sand in coastal systems, the concept has been extended to riverine systems and finer materials to more completely address sources and processes important to sediment management. It also supports many of the recommendations identified by interagency working groups on improving dredged material management. Examining RSM implementation through demonstration efforts can provide lessons not only on improved business practices, techniques and tools necessary for managing resources at regional scales, but also on roles and relationships important to integrated water resources management.

More about RSM can be found in the American Society of Civil Engineers written Policy Statement 522, on Regional Sediment Management at: http://www.asce.org/Content.aspx?id=8638

Beneficial Reuse for Dredging Soils [xi]

Beneficial reuse includes a wide variety of options that utilize the dredged material for some productive purpose. Dredged material is a manageable, valuable soil resource, with beneficial uses of such importance that they should be incorporated into project plans and goals at the project's inception to the maximum extent possible. For example:

- Habitat restoration/enhancement (wetland, upland, island, and aquatic sites including use by fish, wildlife, and waterfowl and other birds);
- Beach nourishment;
- Aquaculture;
- Parks and recreation (commercial and noncommercial);
- Agriculture, forestry, and horticulture;
- Strip mine reclamation and landfill cover for solid waste management;
- Shoreline stabilization and erosion control (fills, artificial reefs, submerged berms, etc);

- Construction and industrial use (including port development, airports, urban, and residential);
- Material transfer (for fill, dikes, levees, parking lots, and roads); and
- Multiple purposes (i.e., combinations of the above).

Detailed guidelines for various beneficial use applications for dredging are given in the USACE Engineering Manual 1110-2-5026 (1987).

Potential Costs of Sediment Management

NOTE TO REVIEWERS - This section of the document answers the question "WHAT DOES IT COST TO DO SEDIMENT MANAGEMENT for Water Benefits?"

Right now I have almost no information on this but I am pretty sure that all of you do. For example, the USACE probably has some pretty good ideas on costs of dredging for navigation, Conservation, NRCS, CalFIRE and Forest Service probably have some pretty good ideas for upland management, and the CSMW probably has a good idea on coastal numbers.

In this section we are just talking about the cost of implementing the strategies. My sense is that we should list this programmatically since the goals of the programs vary.

There may be some benefit in discussion on the costs of environmental documentation to conduct sediment management but I would defer to the group on that.

PLEASE GET ME WHAT EVER YOU CAN ON THIS AS SOON AS YOU CAN.

Special Situations

The battle to retain Lake Tahoe as a pristine visual jewel is an unusual sediment case study. Here the sediment concern is very fine sediment (that less than 20 microns) that affects the clarity (and people's aesthetic enjoyment) of Lake Tahoe. In this case, the problem may be unique and so the extensive costs of Basin-wide improvements would not translate to other situations. Even so, many best practices for sediment management have been pioneered in the Basin and these can translate to other programs.[xii] Additionally the benefits of the investment have been equally evaluated and considered of national interest.

Major Issues Facing Sediment Management

NOTES TO REVIEWERS -

This section needs to meet the following requirements:

1. Explains the major issues facing use Sediment Management as a water manager strategy
2. Sets the stage for recommendations that say things like - "do this ______ to overcome this particular issue."

Please read this section for:

- Accuracy (are descriptions accurately translated from more technical documents into this more general format? If not, what is the correct translation?)
- Accessibility of language (is this written in the right tone and level for the intended audience?)
- Flow of text (does the flow generally make sense?

Achieving and Maintaining Stable (Reference) Sediment Conditions in Watersheds

There is benefit in achieving and maintaining watersheds in a stable condition as it relates to the generation and transport of sediments from the land surface to the surface streams. To do so requires understanding (assisted by geomorphic assessments on channels) and monitoring to determine when watersheds are stable or unstable. Management without these tools cause stream channels to degrade in their geomorphic form and not support the native aquatic biological habitat, and domestic water supplies (filtration). This may also result in disruption of flood control structures.

Achieving Biological Objectives and Maintaining Physical Habitat in Streams

Excessive sediment in streams can be detrimental to the aquatic life. Biological objectives for suspended sediment are being established because of their effect upon the fishery and algae. Efforts are being made to control the deposition and erosion of sediments from the stream channel bottoms because of their effects on aquatic invertebrates. Watershed efforts are needed to control sediment generation and runoff to the streams to meet biological objectives. The State Water Resources Control Board is establishing biological objectives, which will include those for suspended sediment as well as deposited sediments.[xiii] Achieving broad support for establishing and implementing biological objectives is sometimes met with resistance.

Supply of Coarse-Grained Sediments in Streams and Supporting the Fishery

Additional efforts are needed to support the course grained fraction of the natural supply of sediments (sand and gravel), but not the fine-grained sediments (silts and clays) from the watershed to enter the streams and rivers so they can replenish these sediments in fish spawning areas, and also move toward the ocean thereby replenishing the sand along the coastal beaches. Research is needed in this area, as not many techniques now exist for coarse-sediment bypassing in inland watersheds.

In particular, efforts must be made to keep course-grained sediments available and clean in salmon-spawning rivers and streams. Erosion in unstable watersheds brings fine-grained sediments into the channels which may settle and cover the course-grained sediments needed for spawning, thus elimination them from use in the spawning process.[xiv]

Supplying Coarse-Grained Sediments to the Coastal Beaches

Many of the beaches along the coastline are receding because their natural supply of coarse-grained sediments from inland rivers has been stopped by dams, covering of areas by impermeable pavements, stormwater controls, changes to the ground surface, and other land use practices. As noted above, the CSMW, a joint effort of the Army Corps of Engineers and the State of California Resources Agency, is working toward this effort but challenges remain as agencies aim to work collaboratively and overcome the traditional silos that create this dilemma. .

Maintaining Clean Sediments

Clean sediments are those which have not been contaminated by hazardous substances. For a variety of reasons, including control of the source of the substances, keeping these substances out of the waterways and sediment is a challenge. Total Maximum Daily Load (TMDL) documents for clean sediment control in California's waterways are being written by the State Water Resource Control Board.[xv].

Controlling Excessive Sediment From Entering Eutrophic Waterways

Eutrophic waterways typically have a lot of minerals and organic nutrients that benefit plants and algae. They often appear dark and have poor water quality. This occurs when certain nutrients such as phosphorus are absorbed on fine-grained sediments and carried into the waterways and lakes. These nutrients can cause algae blooms in a lake which create a lack of oxygen resulting in fish kills. The sediments themselves result in a reduction in light clarity in lakes, thereby harming the food chain and also reducing the aesthetic quality of the lake. Controlling these conditions is challenging and a failure to do so, especially harmful at Lake Tahoe.

In other cases algae blooms may not kill fish but can introduce substances into the water that make it unfit for consumption and/or create an unappealing algae stew that repels human use, significantly disrupting recreational use. (See Case Study on Clear Lake.)

Handling Contaminated Sediments

Management of contaminated sediments can be challenging. There are limited resources for cleaning of the sediments and disposal or containment of contaminated ones. The USACE has a National Center of Expertise for handing contaminated sediments, at: http://el.erdc.usace.army.mil/dots/ccs/ccs.html.

Some contaminated sediment can be dredged and treated to make it clean. However, some of the sediment is too contaminated to dredge. Such contaminated sediments may be controlled by underwater capping. Capping involves covering contaminated sediment, which remains in place, with clean material. Caps are generally constructed of clean sediment, sand, or gravel. A more complex cap can include geo-textiles, liners, and other permeable or impermeable materials in multiple layers. Caps may also include additions of organic carbon or other in situ amendments to slow the movement of contaminants through the cap. More recent innovative caps have organically or carbon encapsulated in geo-textile mats. This configuration is generally delivered in rolls. It is placed on the contaminated sediments and covered with sand or other conventional cap material to provide suitable habitat and substrate.

Depending on the contaminants and the environment, a cap may reduce risk in the following ways: (1)By physically isolating the contaminated sediment from the overlying water, (2) By stabilizing the contaminated sediment and protecting it from erosion and transport to other areas, and (3) By chemically isolating the contaminants or reducing their movement into the water body (e.g. a reactive cap or one that prevents upwelling groundwater from flowing through the contaminated sediment).[xvi]

Sediment and Climate Change

Sediment impacts are likely to be disproportionate with climate change. Alterations in land cover are already occurring and with it an increase in river basin sensitivity due to accelerated erosion and/or sediment loading. Changes in vegetation occur in response to temperature changes. The cycles of plant life declining and new species encroaching and adapting create long periods of heightened soil exposure. These systems are also far more susceptible to extreme events such as catastrophic fire and high intensity flooding.

In Southern California in particular, storms frequently produce enormous amounts of runoff that spill out onto the flatlands leading to the Pacific Ocean or Mojave Desert. And, if the age-old fire sequence has occurred along the hillsides during the dry months, the rate, composition and amount of runoff are substantially increased. Since the geological composition of the mountain ranges erodes quite easily, a heavy mix of debris is added to the descending storm waters. Adding to this equation is the likely increase in the number and intensity of storm events expected with climate change. These events will amplify the already difficult sediment management situation.

Recommendations to Facilitate Sediment Management

NOTES TO REVIEWERS -

This section needs to meet the following requirements:

1. Provides recommendations that either enhance or support doing more of something beneficial OR support overcoming some issue identified in the Issues section.
2. All recommendations must flow directly from the previous text. So for example there is a recommendation for model ordinances. This has been discussed in various sections of text so this recommendation flows easily from the previous text. Conversely if there were a recommendation to support research and development for new trail building equipment (for example there is new equipment being used to build recreation trails that reduce run-off) this might be a fine idea, but nothing in the text has spoken it to it except some simple references to recreation, so this type of recommendation would not meet this test.

Please review this section for:

- *Your concurrence with the recommendation*
- *The utility of the recommendation for water management*

1. Support the Establishment of Model City and County Ordnances Regarding Sediment Generation and Transport – A new concept is to develop model ordnances to assist city councils and county governments in the planning of their developments such that coarse-grained sediments are not hindered in flowing into the local streams.

2. Support Research and Design of small, medium, and large coarse-grained bypass structures – This will allow the coarse-grained sediment to enter the streams and serve its many beneficial uses there, such as fish spawning and the restoration of coastal beaches.

3. Support Clean Sediment "Total Maximum Daily Load" (TMDLs) Efforts – While the natural sediment supply into streams is considered to be good, the input of excessive sediment can be detrimental to the stream. Sediment TMDLs are being formulated by the State Water Resource Control Board to control such excessive sediment.
4. Reduce Coarse-Grained **(**Sand and Gravel) Permits in Streams – While such permits may be satisfactory in some instances, in other instances such permits affect fish spawning beds and beach replenishment along the coast.

5. Support Regional Sediment Management – For those sediments which must be dredged to keep the waterways open to navigation or to support flood control efforts, make efforts to use that sediment beneficially within the region.

6. Support the Regulatory Management of Sediment in Stormwater Runoff recommended by the California Association of Storm Water Quality Agencies (CASQA) for stormwater discharge control programs which are (1) technically and economically feasible, (2) provide significant environmental benefits and protect the water resources, (3) promote the advancement of stormwater management technology, and (4) effect compliance with State and Federal laws, regulations and policies

CASE STUDY - California American Water files application for removal of silted-up dam - dredging not feasible

http://www.sandandgravel.com/news/article.asp?v1=13621

News - September 27, 2010

California American Water has filed an application with the California Public Utilities Commission requesting permission to remove the San Clemente Dam on the Carmel River in order to resolve seismic safety concerns associated with the dam and restore critical habitat for the steelhead trout.

“From an engineering and environmental perspective, this is a landmark project,” said California American Water president Rob MacLean. “Our innovative method for dealing with the sedimentation behind the dam and the level of public-private cooperation which has made this plan a reality will serve as a template for the removal of other obsolete dams across the country.”

California American Water is partnering with the National Oceanic and Atmospheric Administration’s National Marine Fisheries Service and the California State Coastal Conservancy to implement the dam removal project while minimizing cost to its ratepayers. California American Water has committed $49 million and the dedication of 928 acres where the dam is located as parkland.

The Coastal Conservancy and NOAA committed to raise the additional $35 million needed for the removal project through a combination of public funding and private donations.

The San Clemente Dam is a 106ft high concrete-arch dam built in 1921, 18 miles from the ocean on the Carmel River, to supply water to the Monterey Peninsula’s then-burgeoning population and tourism industry. Today the reservoir is over 90 percent filled with sediment and has a limited water supply function.

In 1991, the California Department of Water Resources, Division of Safety of Dams agreed with a California American Water consultant’s assertion that San Clemente Dam did not meet modern seismic stability and flood safety standards.

The Department of Water Resources and Army Corps of Engineers studied many ways to ameliorate the safety issues including strengthening the dam and removing it.

The January 2008 Final Environmental Impact Report and Environmental Impact Statement (“EIR/EIS”) regarding San Clemente Dam’s stability contains analysis of a Reroute and Removal Project, which would address the seismic and flood safety risks associated with San Clemente Dam by permanently rerouting a portion of the Carmel River and removing the dam.

Under this proposal, the Carmel River would be rerouted to bypass the 2.5 million cubic yards of silt that have accumulated behind the dam thereby avoiding dredging, which has been deemed infeasible.

The primary benefits of the Reroute and Removal Project are that it improves the Carmel River environment by removing the dam, which serves as a barrier to fish passage, and satisfies government agencies' concerns that strengthening the dam, as opposed to removing it, could further threaten the South Central California Coast Steelhead and violate the federal Endangered Species Act.

CASE STUDY - CLEAR LAKE - Algae in Clear Lake

[http://www.co.lake.ca.us/Government/Directory/Water_Resources/Algae_in_Clear_Lake.htm]

The Clear Lake Basin was shaped by a variety of processes over the last 1 to 2 million years. Scientists have recovered a nearly continuous sequence of lake sediments dating back 475,000. Other lake sediments in the region that date back to the Early Pleistocene, approximately 1.6-1.8 million years ago.

There is an excellent climate record from these cores for the last 127,000 years. The record documents a shift from pine dominated to oak dominated forests at the end of the Pleistocene Glacial Period 10,000 years ago, indicating a warming trend. The diatom sequence in these cores indicate that Clear Lake has been a shallow, productive system, essentially similar to the modern lake since the end of the Pleistocene Period.

The basin was created primarily from the stresses of the San Andreas Fault System, the eruption and subsidence of the Clear Lake Volcanics, and the erosion and deposition of the parent rock. The east-west extension of the fault system and vertical movements of the faults created and maintained the basin. Downward vertical movement within the basin created by these processes is at a rate approximately equal to the average sedimentation rate of 1/25 inch/year in the lake basin.

Since these rates are essentially equal, a shallow lake has existed in the upper basin for at least the last 475,000 years. If sedimentation rates were significantly different from the downshift, then either a deepwater lake or a valley would have resulted. Although the lake has changed shape significantly over this period, it has generally been located in the same area as the existing Upper Arm.

Clear Lake is a naturally eutrophic lake. Eutrophic lakes are nutrient rich and very productive, supporting the growth of algae and aquatic plants (macrophytes). Factors contributing to its eutrophication include a fairly large drainage basin to contribute mineral nutrients to the water, shallow and wind mixed water, and no summertime cold water layer to trap the nutrients. Because of the lake's productivity, it also supports large populations of fish and wildlife.

The algae in Clear Lake are part of the natural food chain and keep the lake fertile and healthy. Because of the lake's relative shallowness and warm summer temperatures, the algae serve another important purpose. They keep the sun's rays from reaching the bottom, thus reducing the growth of water weeds which would otherwise choke off the lake.

Along with Clear Lake's high productivity, algae in the lake can create a situation which can be perceived as a problem to humans. Algae are tiny water plants that cycle normally between the bottom and the surface, floating up and sinking down. During the day, algae generate oxygen within the lake; at night they consume oxygen.

Nuisance blue-green algae, however, can be a problem. From more than 130 species of algae identified in Clear Lake, three species of blue-green algae can create problems under certain conditions. These problem blue-greens typically "bloom" twice a year, in spring and late summer. The intensity of the blooms vary from year to year, and are unpredictable. The problem occurs when algae blooms are trapped at the surface and die. When this occurs, unsightly slicks and odors can be produced.

It does not appear that blue-green algae are a recent development in Clear Lake.

Sediment cores collected from the bottom of Clear Lake by the United States Geological Survey (USGS) indicate Clear Lake has been eutrophic with high algal populations since the last ice age, which ended approximately 10,000 years ago. The graph shows the change in algae pollen over time from a core in the Upper Arm.

Livingston Stone, a fisheries biologist, visited Lake County in 1873 and reported to Congress that Clear Lake had significant algal populations at the time.

It is a singular fact, illustrating the inaptness with which names are often given to natural objects, that the water of Clear Lake is never clear. It is so-cloudy, to use a mild word, that you cannot see three feet below the surface. The color of the water is a yellowish brown, varying indefinitely with the varying light. The water has an earthy taste, like swamp-water, and is suggestive of moss and water-plants. In fact, the bottom of the lake, except in deep places, is covered with a deep, dense moss, which sometimes rises to the surface, and often to such an extent in summer as to seriously obstruct the passage of boats through the water.

He further describes water conditions in September as:

Fish and fishing are about the same as in August. The weather is a little warmer. No one fishes during this month except the Indians, who still keep after the trout. The water this mouth is in its worst condition. It is full of the frothy product of the soda-springs. A green scum covers a large part of the surface, and it is not only uncleanly to look at, but unfit to drink; and yet, strangely enough, this lake, which one would think uninhabitable by fish, fairly teems and swarms with them.

These descriptions appear to describe blue-green algae and conditions similar to that in the last 20 years. The “moss” described in the first passage could be rooted plants or the filamentous algae *Lyngbya*, which behaves in a similar manner. Regardless, this moss indicates a relatively clear lake if sunlight is penetrating sufficiently to promote growth of “moss” on the bottom. The full text of Stone’s writings about Clear Lake are available here.

Other historical accounts indicate the lake was relatively clear through 1925. Substantial declines in clarity and increases in scum forming algae (blue-green algae) occurred between 1925 and 1939. An increase in nutrient loading from increased erosion, fertilizer and wastewater discharges due to urban and agricultural development were the probable causes of increased blue-green algal growth.

The advent of powered earthmoving equipment increased the amount of soil disturbance and facilitated large construction projects, such as the Tahoe-Ukiah Highway (State Highway 20), the reclamation of the Robinson Lake floodplain south of Upper Lake, stream channelization and the filling of wetlands along the lake perimeter. To support the development, gravel mining increased within the streams , further increasing erosion and sediment delivery to Clear Lake. During this time period, mining techniques at the Sulphur Bank Mercury Mine changed from shaft mining to strip mining, resulting in the discharge of tens of thousands of yards of overburden directly into Clear Lake.

Limnological studies of Clear Lake began in the early 1960's to determine the causes of the high productivity in Clear Lake. It was found that the lake is nitrogen limited in the summer, with a great excess of phosphorus within the system. Phosphorus in the water column comes from both the annual inflows and nutrient cycling from the lake sediments. Nitrogen limitation does not affect many blue-green algae, as they were able to utilize (fix) nitrogen from the atmosphere, and consequently have an essentially unlimited supply of nitrogen. This gave these blue-green algae a competitive advantage, and *Anabaena* and *Aphanizomenon* dominated the lake during the summer. A third blue-green algae, Microcystis, also occurred in significant quantities. During this time period, it was also determined that iron was a limiting micro-nutrient.

Starting in the summer of 1990, lake clarity improved significantly. This improved clarity has continued until the present. This graph shows the Secchi Depth (the depth into the water at which a black and white checked plate is visible) in the Upper Arm from 1969 through 2008.

During the 1991-1994 time period, University of California researchers led by Drs. Peter Richerson and Thomas Suchanek analyzed lake water quality data collected for the previous 15 years, conducted experiments and evaluated the Clear Lake system. Unfortunately, little data was available during the period of improved clarity since 1990. The "Clean Lakes Report" determined that excess phosphorus is a major cause, however, iron limits the growth of blue-green algae. The improved water clarity and reduced blue-green algal blooms continued into the new millennium. DWR data collected since the Clean Lakes Report was evaluated by Lake County staff in 2002. Surprisingly, phosphorus and total nitrogen concentrations in the lake did not change substantially when the lake clarity increased. Cursory review of the data did not provide evidence of chemical changes that led to the improved clarity and reduced blue-green algal blooms in Clear Lake.

Other

Possible Photos:

Oxbow Lake/ - Butte County - Sacramento River - http://creagrus.home.montereybay.com/CA-BUT.html

(Jeff Mount)
BRAIDED RIVER
Fig. 4.4. 1953 USDA aerial photograph of lower Cache Creek, Yolo County,

California. This steep-gradient, bedload-dominated river occupies multiple, actively migrating channels during bankfull discharge events, forming an extensive braid plain. Intense aggregate mining has greatly disrupted the sediment budget for this river, creating a number of land use issues.
http://www.ucpress.edu/excerpt.php?isbn=9780520202504

Fig. 4.3. 1952 aerial photograph of Sacramento. Note Also note extensive vegetated riparian

Sacramento River in Glenn County, north of meandering single channel pattern of river. point bar development and heavily corridor.

References Cited

End references for any works cited in your text appear here.

[i] source - http://www.oceancommission.gov/documents/full_color_rpt/12_chapter12.pdf

[ii] http://www.epa.gov/owow/NPS/lidnatl.pdf, http://www.epa.gov/region1/topics/water/lid.html, http://efc.muskie.usm.maine.edu/docs/lid_fact_sheet.pdf, and http://www.huduser.org/publications/pdf/practlowimpctdevel.pdf, with model regulations at http://www.mass.gov/envir/smart_growth_toolkit/bylaws/LID-Bylaw-reg.pdf

[iii] Need reference for California Dam numbers.

[iv] Source: http://www.usbr.gov/pmts/sediment/kb/ErosionAndSedimentation/chapters/Chapter8.pdf

[v] ibid

[vi] ibid

[vii] Source: http://www.bcdc.ca.gov/pdf/Dredging/EIS_EIR/chpt3.pdf

[viii] More detailed descriptions of dredging equipment and dredging processes are available in Engineer Manual (EM) 1110-2-5025 (USACE 1983), Houston (1970), and Turner (1984).

[ix] Lands (including the minerals and sediment of those lands) under the ocean and under navigable streams are owned by the public and held in trust for the people by government. Because public trust lands are held in trust for all citizens of California, they must be used to serve statewide, as opposed to purely local, public purposes.

[x] http://landresources.montana.edu/SWM/PDF/Final_proof_SW3.pdf

[xi] http://www.bcdc.ca.gov/pdf/Dredging/EIS_EIR/chpt3.pdf

[xii] The relatively gross estimates of capital costs for implementation for the entire Tahoe Basin for the first 20 years is estimated at $1.5 billion, with annual operation and maintenance at more than $10 million.

[xiii] A web site containing this information is available at: http://www.waterboards.ca.gov/plans_policies/biological_objective.shtml

[xiv] A web site describing these needs is at: http://www.joewheaton.org/Home/research/projects-1/past-projects/spawning-habitat-integrated-rehabilitation-approach-shira-

[xv] Info on the control of clean sediments is here: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/NSLReport17.pdf

[xvi] An USEPA web site on capping and other items pertaining to contaminated sediment is at: http://clu-in.org/contaminantfocus/default.focus/sec/Sediments/cat/Remediation/p/1

Other References

CalFIRE

http://www.bof.fire.ca.gov/board_committees/monitoring_study_group/msg_supported_reports/2009_supported_reports/38_-_wilzbach_and_cummins_2009_cdf_final_stream_health_report.pdf

http://www.bof.fire.ca.gov/board_committees/monitoring_study_group/msg_archived_documents/msg_archived_documents_/buffleben_2009_ucla_dissertation.pdf

Water Boards

SCCWRP report at ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/667_CA_HydromodMgmt.pdf on hydromodification, which includes discussions on sediment.

Lake Tahoe TMDL Report (http://www.waterboards.ca.gov/lahontan/water_issues/programs/tmdl/lake_tahoe/docs/tmdl_rpt_nov2010.pdf), & Sediment load reduction and associated costs (http://www.waterboards.ca.gov/lahontan/water_issues/programs/tmdl/lake_tahoe/docs/iwqms_proj_report.pdf & http://www.waterboards.ca.gov/lahontan/water_issues/programs/tmdl/lake_tahoe/docs/presentations/pro_report_v2.pdf).

Personal Communications